# Assimilation of passive and active microwave soil moisture retrievals

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Root-zone soil moisture is an important control over the partitioning of land surface energy and moisture. Previous studies have demonstrated that assimilating remotely sensed near-surface soil moisture can improve model profile soil moisture. These studies have focused on soil moisture data derived from either the passive microwave Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) or the active microwave Advanced Scatterometer (ASCAT; or its predecessors).

Here, the assimilation of ASCAT and AMSR-E soil moisture is compared for the first time. For ASCAT, observations from the Technical University of Vienna are used, while for AMSR-E, X-band observations from the Free University of Amsterdam are used. Each of these data sets are assimilated over 3.5 years into the NASA Catchment land surface model, using an Ensemble Kalman Filter (EnKF). Soil moisture skill from each assimilation experiment is assessed against in situ soil moisture observations from the SCAN/SNOTEL network in the US (66 sites) and the Murrumbidgee Soil Moisture Monitoring Network in Australia (19 sites). Soil moisture skill is measured as the anomaly time series correlation coefficient with the in situ data (R).

Figure 1 shows the estimated R values and their 95% confidence intervals for the surface and root-zone soil moisture, from the assimilation of ASCAT, AMSR-E and both. The results are benchmarked against an open-loop, and have been averaged by land cover type (based on MODIS land cover classifications). Across all 85 sites, assimilating ASCAT and/or AMSR-E data significantly improved the soil moisture skill (at the 5% level). In the root-zone, the mean skill was increased from 0.45 for the open-loop, to 0.55 for the assimilation of ASCAT, 0.54 for the assimilation of AMSR-E, and 0.56 for the assimilation of both.

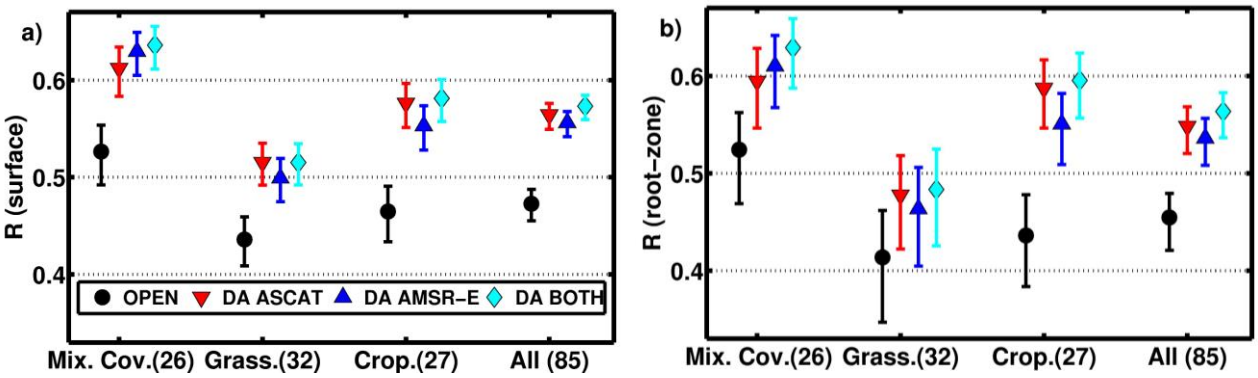


*Figure 1: Mean skill for a) surface and b) root-zone soil moisture from the OPEN-loop (ensemble mean, no assimilation), and the data assimilation (DA) of ASCAT, AMSR-E, and BOTH, averaged by land cover class, with 95% confidence intervals. The number of sites in each land cover class is given in the axis labels. Skill is based on all nonfrozen days in the experiment period.*

Assimilating the ASCAT or AMSR-E data also improved the mean R value over each individual land cover type, in most cases significantly. At the frequencies observed by AMSR-E and ASCAT, dense vegetation limits the accuracy of soil moisture observations, and so the improvements obtained over the mixed cover sites, which have 10-60% trees or wooded vegetation, are very encouraging. For each land cover type, the skill obtained from the assimilation of ASCAT or AMSR-E was very similar. Following the recent malfunction of the AMSR-E instrument, applications currently assimilating AMSR-E should then be able to switch to ASCAT data without loss of accuracy.

The combined assimilation (ASCAT and AMSR-E) generally matched or slightly exceeded the mean R from the single-sensor assimilation experiments. Consequently, for maximum accuracy and spatial coverage it is recommended that passive (AMSR-E or WindSat) and active (ASCAT) near-surface soil moisture be assimilated together, if possible.

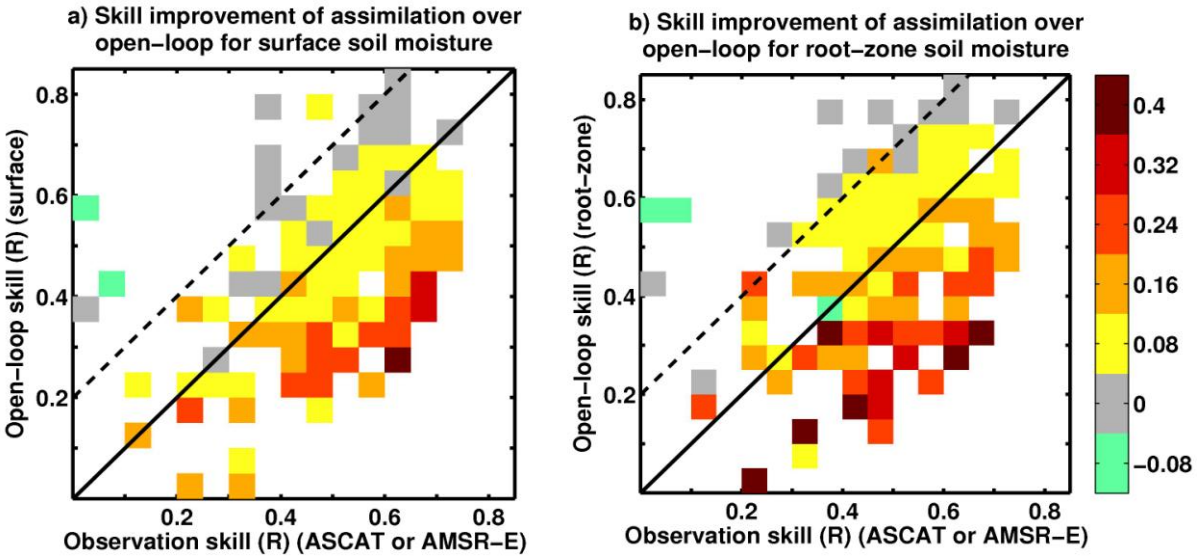


*Figure 2: Skill improvement ($\Delta R$) from assimilating either ASCAT or AMSR-E for a) surface and b) root-zone soil moisture, as a function of the open-loop and observation skill. Skill improvement is defined as the skill of the assimilation product minus the open-loop skill, with skill based only on days with data available from both satellites*

Finally, the contribution of the model and observation skill to the skill of the assimilation output was also examined. Figure 2 shows the skill increase ($\Delta R$) relative to the open-loop model from the single-sensor assimilation of ASCAT or AMSR-E, as a function of the R of the open-loop and of the assimilated (ASCAT or AMSR-E) observations. In general, for a given combination of open-loop and observation skill, the skill gained through assimilation was slightly higher for the root-zone (Figure 2b) than for the surface soil moisture (Figure 2a). Also, where the satellite soil moisture skill was no more than 0.2 less than the open-loop skill (below the dashed lines), the assimilation improved the soil moisture skill, with larger improvements (up to 0.4) obtained as the observation skill increased relative to that of the open-loop. This result provides a practical demonstration of the minimum skill required for soil moisture observations to be beneficial in GMAO's land surface assimilation system.

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